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BREEDING SITES OF SOME SPECIES OF *ZAPRIONUS* (DIPTERA) IN UGANDA

By

J. H. Buruga

Botany Department, Makerere University, P.O. Box 7062, Kampala, Uganda

INTRODUCTION

Zaprionus Coquillett belongs to the family Drosophilidae (Diptera). A large family with many genera, mostly tropical, it contains many common species which tend to be fruit "pests".

Because the most widespread genus within the family is *Drosophila*, much information has been collected on the breeding and feeding habits within the genus. The principal breeding sites for the *Drosophila* are various materials containing naturally occurring carbohydrate substrates. These vary from fruits, barks, exudates and rotting leaves to fleshy fungi. It has been shown (Carson & Stalker 1951) that yeasts, associated bacteria and related micro-organisms, which thrive on these materials, form the main food supply for both adults and larvae of many species of the genus.

Cosmopolitan species such as *D. melanogaster* Meigen, *D. simulans* Sturtevant, *D. immigrans* Sturtevant, and *D. busckii* Coquillett have been bred from garbage, rotting fruits and other habitats usually associated with domestication. Most of the wild species of *Drosophila* require specialised breeding sites, but some can breed in 'domestic' breeding sites. Examples of truly wild species of *Drosophila* which have been found in fleshy fruits are *D. affinis* Sturtevant and *D. tripunctata* Loew. These have been reared from rotting fruits of the May Apple *Podophyllum peltatum*. *D. athabasca* Sturtevant & Dobzhansky was bred from rotting persimmons *Diospyros virginiana* together with *D. melanogaster* Meigen and *D. simulans* Sturtevant (Carson & Stalker 1951).

D. americana Spencer was found breeding in the bark of *Salix interior* (Blight & Romano 1953); *D. laciola* Patterson bred on rotting phloem of *Populus tremuloides* Michx (Spieth 1951). Exudates from trees have also been used as breeding sites for *Drosophila*. Gordon (1942) bred *D. obscura* Fallen from the exudate of elm trees. *D. persimilis* Dobzhansky & Epling and *D. pseudoobscura* Frolova were found breeding in the fluxes of *Quercus kellogii* together with *D. victoria* Sturtevant and *D. californica* Sturtevant (Carson 1951). Fleshy fungi, especially the larger agarics, have yielded such Drosophilidae as *D. tripunctata* Loew and *D. transversa* Fallen (Carson & Stalker 1951).

Preliminary work in Uganda (Buruga & Olembo 1971; Tallantire & Buruga 1971), confirmed that many wild species of *Drosophila* have similar breeding sites. In addition, Aubertin (1937), found the larvae of *D. gibbinsi* Aubertin living together with *Simulium* larvae in an aquatic situation at Jinja. The gut contents of these larvae showed that they were carnivorous. Other genera of Drosophilidae were found breeding in very specialised sites. For example, Odhiambo (1958) found *Leucophanga* sp. indet. near Sema Burla breeding in the frothy fluid secreted by nymphs of *Ptyleus flavescens* F. (Homoptera, Cercodae).

Carson (1965) has discussed the importance of a full understanding of the ecological niches of the Drosophilidae to appreciate the evolutionary trend of the species. Since Sturtevant (1921), this has been a much neglected area. Sturtevant (1918) also pointed out the possibility of medical significance in such studies. In the Ivory Coast of West Africa Lachaise and Tsacas (1974) and Lachaise (1974) have done much work on the ecology of Drosophilidae, including that of *Zaprionus*.

Much of the ecological genetics of African Drosophilidae, however, remains to be worked out. This work on *Zaprionus* represents an initial effort in understanding the ecology of locally occurring Drosophilidae.

ZAPRIONUS COQUILLETT

Over 15 species of *Zaprionus* have already been described from Africa and southern Asia. *Z. vittiger* Coq. and *Z. ghesqurerei* Collart have been recorded from various parts of Africa, together with a number of other species. Okada (1964) records *Z. obscuricornis* (de Moijere) from Borneo, Sumatra, Java and the Phillipine Islands in Southeast Asia. The Zaprionids can be readily recognised by the characteristic white stripes on the head, the mesonotum, and the scutellum. Ecological work has, however, been scanty and more information is required on the breeding and feeding habits of *Zaprionus*. This work in Uganda hopes to contribute to this body of knowledge. Breeding and feeding sites investigated followed closely the pattern studied in *Drosophila* and also included nectar-containing flowers.

METHODS

Materials collected in the field were brought into the laboratory and kept in clean glass containers stoppered with heat-sterilised cotton wool. The containers were examined daily for several weeks for Drosophilidae. Sometimes larvae found in the material were transferred to cornmeal-agar media. Also traps were set, of bananas, pawpaws, pineapples and tomatoes.

COLLECTION AREAS

Sites investigated for Drosophilidae included cultivated, forest and savannah areas.

Cultivated areas

Material was collected from the Botany Garden at Makerere where both indigenous and introduced plants are cultivated. It is constantly weeded and thinned and being easily accessible was found suitable for the study of Drosophilidae.

Forests

Several forests were sampled. Mpanga forest, 37 km west of Kampala at an altitude of between 1143 m and 1204 m is a moist evergreen forest. Mabira forest, 22 km east of Kampala, is a semi-deciduous forest at an altitude of 1216 m. Budongo forest, also semi-deciduous, lies at about the same altitude; it is situated approximately 200 km north of Kampala. These forests receive an annual rainfall of between 143 cm and 175 cm. A large number of plant species, most of them indigenous, are found in them. Because of the moist atmosphere and the canopy, many types of fungi and other soil macroflora are present.

Savannah

Two savannah areas were studied. Kaazi, at an altitude of about 1240 m, is situated on Lake Victoria and receives an annual rainfall of 70 cm–100 cm. Arua, in northern Uganda, rises up to 1204 m and receives a maximum rainfall of 700 mm.

RESULTS

The total number of *Zaprionus* species obtained, is shown in Table 1. At least eight different species have so far been identified. These were obtained by trapping or by breeding them out of various organic materials.

Zaprionus species breeding in flowers

Flowers from several plant families were examined (Table 2). At least four species of *Zaprionus* were obtained, the commonest being *Z. tuberculatus*. Although the species *Z. vrydaghi* has been observed feeding on the flowers of *C. afer* in Budongo and Mabira forests, it has never been found breeding in flowers of *Costus afer* from the Botany Garden, Makerere.

Table 1

Zaprionus *species in Uganda*

Species	Origin	Locality
Z. ghesquierei Collart	Fruits Flowers Traps	Botany Garden Nabugabo Camp Ziika Forest
Z. inermis Collart	Traps	Botany Garden Ziika Forest
Z. koroleu Burla	Traps	Botany Garden
Zaprionus sp. near *koroleu* but with tuberculate femur	Traps	Botany Garden
Zaprionus sp. c.f. *spinosus* Collart (possibly a new species)	Traps	Ziika Forest Arua
Z. tuberculatus Malloch	Fruits Flowers Traps	Botany Garden Nabugabo Camp Ziika Forest
Z. vittiger Coq	Fruits Flowers Traps	Arua Botany Garden Nabugabo Camp Ziika Forest
Z. vrydaghi Collart	Flowers	Budongo Forest Mabira Forest
Zaprionus species (Unidentified)	Feeding on exudates	Mpanga Forest

Table 2

Representative species of plant families from whose flowers Drosophilidae were reared

Family	Species	*Zaprionus* species	Locality
Apocynaceae	*Tabernaemontana holstii* K. Schum.	*Z. tuberculatus*	Makerere
Bignoniaceae	*Spathodea nilotica* P. Beauv.	*Z. tuberculatus*	Makerere
Convolvulaceae	*Ipomoea tricolor* Cav.	*Z. vittiger*	Makerere
Leguminosae	*Erythrina abyssinica* Lam.	*Z. tuberculatus*	Makerere Kigezi
Malvaceae	*Gossypium hirsutum* L.	*Z. tuberculatus*	Kawanda
Moraceae	*Treculia africana* Decne.	*Z. tuberculatus*	Ziika Forest
Passifloraceae	*Passiflora* sp.	*Z. vittiger*	Makerere
Zingiberaceae	*Costus afer* Ker-Gawl. *Costus spectabilis* (Fenzl) K. Schum.	*Z. vrydaghi* *Z. tuberculatus* *Z. vittiger* an unnamed *Zaprionus* sp.	Mabira Forest Botany Garden Makerere

Zapriopus species breeding in fruits

A large number of ripe and decaying fruits were collected. Fruits were of indigenous plants, particularly of families Moraceae and Solanaceae, and of introduced plants. Most of the fruits collected from indigenous plants were from the forest and savannah areas. These fruits were usually collected because Drosophilidae were seen to feed on them. The results are presented in Table 3.

Table 3

Plant species from whose fruit Zaprionus *were obtained*

Zaprionus species	Plant species	Locality
Z. ghesquierei	*Averrhoa carambola* L.	Botany Garden, Makerere
	Carica papaya L.	,,
	Cyphomandra betacea Sendth.	,,
	Ficus brachypoda Hutch.	,,
	Mangifera indica L.	Arua
	Musa sp. (Banana)	Botany Department
	Persea americana Mill (Avocado)	Botany Garden, Makerere
	Solanum gilo Raddi	,,
		Nabugabo
Z. tuberculatus	*Aframomum sanguineum* K. Schum.	Botany Garden, Makerere
	Averrhoa carambola L.	,,
	Coffea canephora Frochner.	Kawanda
	Cyphomandra betacea Sendtn.	Botany Garden, Makerere
	Eriobotrya japonica Lindl.	,,
	Ficus mucuso Ficalho	,,
	Mangifera indica L. (Mango)	Makerere, Budongo
	Phytolacca dodecandra L'Herit.	Buto Forest
	Psidium guajava L. (Guava)	Botany Garden, Makerere
	Solanum gilo Raddi	,,
	Solanum verbascifolium L.	Kyambogo
	Solanum sp.	Budongo Forest
	Unidentified (Rosaceae)	Mulago
Z. vittiger	*Anona* sp.	Arua
	Aframomum sanguineum K.Schum.	Nabugabo
	Ananas sativus (Pineapple)	,,
	Artocarpus communis Forst.	Entebbe
	Averrhoa carambola L.	Botany Garden, Makerere
	Carica papaya L. (Pawpaw)	,,
	Coffea canephora Froehner (Coffee)	Nabugabo
		Kawanda
	Cyphomandra betacea Sendtn.	Botany Garden, Makerere
	Eriobotrya japonica Lindl.	,,
	Ficus brachypoda Hutch.	Botany Garden/Entebbe
	Ficus mucuso Ficalho.	Budongo & Mabira Forests
	Ficus urceolaris Hiern.	Mpanga Forest
	Lantana camara L.	Kyambogo
	Mangifera indica L. (Mango)	Arua; Budongo; Makerere
	Psidium guajava L. (Guava)	Botany Garden, Makerere
	Rubus steudneri Schweinf.	,,
	Solanum gilo Raddi	,,
	Solanum campylacanthum Hochst.	,,
	Solanum verbascifolium L.	Kyambogo
	Solanum sp.	Budongo
	Unidentified (Rosaceae)	Mulago

Stems and barks of trees

Although a large collection of bark and stems of various plants was made, no *Zaprionus* species was seen to feed on or breed out of them.

Fluxes

Forest trees were examined for exudates. In *Albizia gummifera* (Gmel) exudate flow that had been caused by slicing the bark, Drosophilid-like larvae were found crawling about. Adults of a *Zaprionus* species were seen to swarm around and feed on the flux. It was assumed that this pecies of *Zaprionus* bred on the fluxes of *A. gummifera.* Adult *Zaprionus* species were captured from these fluxes in Mpanga forest. Attempts to raise them on cornmeal-agar media were unsuccessful. The larvae from these exudate flows were brought into the laboratory but could not be made to develop further on artificial media. It has so far been impossible to show whether these *Zaprionus* species were just feeders on the flux of *A. gummifera* or whether they bred in it too.

Fleshy fungi

A number of Drosophilids were bred from fleshy fungi, but no *Zaprionus* species were found. Many larvae were found infesting some of the agaric collections from Mpanga forest; attempts to raise these larvae on cornmeal-agar or banana-agar media were unsuccessful.

Rotting leaves

Collections of rotting leaves yielded some species of *Leucephanga* together with other Drosophilidae, but no *Zaprionus* was found.

CULTURING *ZAPRIONUS* IN THE LABORATORY

Not all species of *Zaprionus* collected from the field could be bred on artificial media. *Z. ghequierei*, *Z. inermis*, *Z. tuberculatus* and *Z. vittiger* have, however, been cultured on cornmeal-agar media. Whereas the other species of *Zaprionus* have a life cycle of about two weeks at room temperature (25°C–27°C), *Z. vittiger* has a life cycle of between nine and eleven days. *Zaprionus* species that bred in flowers and those that bred in exudates would not breed in cornmeal-agar media nor in banana-agar media. They have, however, been maintained on these media for about two weeks, at the end of which they all died. Zaprionids such as *Z. vittiger*, *Z. ghesquierei*, and *Z. tuberculatus* which bred on both wild and cultivated fruits are easily cultured in the laboratory, whereas those that only breed in wild flowers are not.

DISCUSSION

Like *Drosophila*, *Zaprionus* has been found to breed in various carbohydrate substrates. However, the main breeding sites for the commoner species of *Zaprionus* appear to be fleshy fruits. Large fleshy fruits yielded the greatest number of Zaprionids. This may be because such fruits have adequate moisture and take a long time to dry out and disintegrate, giving the Zaprionids ample time to undergo their life-cycles. Fruits from which no Zaprionids were bred tended to be small and often dried out quickly.

Some of the *Zaprionus* species such as *Z. vittiger* and *Z. tuberculatus* were found over a wide area from which collections were made. Some Zaprionids tended to be restricted to certain ecological areas: *Z. vrydagi* was taken from all the forests from which collections were made and was never collected from other ecological areas.

Some of the fruit collections were interesting in that in some areas they yielded *Zaprionus* species, while in others they did not. Zaprionus was found in *Lantana camara* from Kyambogo but not found in this plant collected from Arua and Makerere. Likewise *Ficus urceolaris* Welwo was collected from Budongo forest, Makerere and Mpanga forest, but *Zaprionus vittiger* was found only from the Mpanga material. *Z. vittiger* and *Z. tuberculatus* have been bred from fruits of *Coffea canephora* Pierre collected from Kawanda but not from Makerere. Most of the fruits collected are seasonal. However, there is usually a long period in the fruiting of members of the same species. Different plants tend to have different fruiting seasons in some cases. This means that there is always some food and a breeding site for *Zaprionus*. These Drosophilidae can therefore breed throughout the year with peak periods when fruits are more plentiful. The peak of the breeding season for *Z. vittiger* and *Z. tuberculatus* appears to be in the May–June–July period when many plants are in fruit. In all the species, the period of least breeding activity is the November–December–January period, when very few plants are fruiting.

Some of the *Zaprionus* species have been found to breed in flowers of various plants, but this may not be a very important breeding site. The smell of the flowers that have opened out appear to attract the *Zaprionus* together with other flies. The flowers collected, however, were not highly perfumed, although all of them contained nectar. Female Zaprionids appear to lay eggs in the flower during the course of feeding. These eggs develop in a few days to form larvae which are then active feeders by the time the flower withers and rots. It is possible that yeast and other micro-organisms, thriving on the rotting corolla of the flowers, provide enough food for the growth and development of the larvae. By the time the flower dries, the larvae have pupated. When the *Zaprionus* merge from the pupa, they then fly away in search of food. In the laboratory, the average period of development of the larvae of three *Zaprionus* species studied is five days. Flowers of *Costus spectabilis*, and presumably those of the other species of *Costus*, take over two weeks to dry up.

Fluxes of trees have so far not been shown to provide breeding sites for *Zaprionus* although they appear to be used for feeding by one species of *Zaprionus*. It was shown that this species of *Zaprionus* tended to frequent fresh exudates of *Albizia gummifera*, while *Mycodrosophila bombax* Burla tended to frequent the older exudates of the same tree. Carson (1951) has suggested that micro-biological flora of exudates offers breeding and feeding sites with differential qualities of attraction for the different species of *Drosophila*. It may be that the *Zaprionus* species prefers the micro-flora and fauna that inhabit the fresh exudates of *A. gummifera* to those that inhabit the older exudates of the same tree species.

From the foregoing discussion, *Zaprionus* species can be grouped arbitrarily into "domestic" and "wild" types. The former, represented by *Z. vittiger* and *Z. tuberculatus* feed on and breed in a wide variety of sites. They are widespread and occur in man-made habitats as well as in the wild. On the other hand, *Z. vrydagi* and two unnamed species of *Zaprionus* appear to be more specific in their choice of breeding and feeding sites. They are the "wild" species of *Zaprionus*.

SUMMARY

Work done on *Zaprionus* in Uganda shows that many of the species bred in ripe fruits, which would therefore seem to be the principal breeding sites. They also bred in flowers. None have so far been shown to breed in the stem and barks of trees, fluxes, rotting leaves or fleshy fungi. As in *Drosophila*, *Zaprionus* species seem to have both "domestic" and "wild" types.

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